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ANALYSIS OF SATELLITE COMMUNICATION MARKET IN CHINA

Min Zhangning Bao Miaoqin

Translation of "Wo Guo Wei Xing Tong Xin Shi Chang Fen Xi"; Aerospace China, No.12, December 1993, pp 3-6

Following along with the development of China's national economy, growth in communications requirements is very rapid, creating for a time a shortage of satellite communications resources domestically and phenomena associated with transponders not supplying demand. Through several years of efforts in various areas, the conditions associated with Chinese satellite communications will, in the short term, achieve comparatively great improvements. Due to the Zhongxing No.5 satellite going into service, at the present time, communications transponders utilized domestically in China have already reached 30. As far as preliminary changes for satellite transponders associated with domestic use are concerned, approximately half are in statuses associated with the renting of foreign satellites. With regard to the domestically developed East Is Red No.3 (simply called East 3) satellite, first launch can be expected in 1994. The Hongkong Asia Pacific communications company, which has invested heavily domestically, has purchased U.S. Hughes 376 model satellites. The AP-STAR-1 (Asia Pacific No.1) satellite will be launched in June 1994. Its large beam not only covers the Southeast Asia area. Moreover, it also covers the whole territory of China. It is also capable of being partially used domestically.

The Zhongxing No.5 satellite was launched in 1984. At the present time, it has already "exceeded service period". However, its fuel, carried on board the satellite, can roughly be used until the end of 1996. The East 3 satellite's life is more than 8 years. The AP-STAR-1's life is 9-10 years.

As far as a full understanding of the current status of satellite communications and development requirements is concerned, an analysis is done of supply demand relationships associated with the civilian satellite communications market before the year 2000 with regard to promoting the development of China's communications satellites and satellite communications activities to satisfy the requirements of the domestic satellite communications market. New communications satellite development projects which have been drawn up are all significant.

I. UTILIZATION AND REQUIREMENTS ASSOCIATED WITH SATELLITE COMMUNICATIONS TRANSPONDERS AT THE PRESENT TIME

At the present time, there is a total of 24 civilian transponders in the process of being utilized. This includes two

educational television repeaters associated with the Chinese East Is Red No.2A (simply called East 2A) satellite, 5 transponders associated with the Asia No.1 satellite, as well as 16 transponders associated with the Zhongxing No.5. There is also 1 transponder associated with the international space organization satellite (ST-14). These transponders are used in television broadcast programming and communications activities associated with public communications networks and specialized communications networks. According to understandings, actual satellite communications requirements at the end of 1993 far, far exceed the transponders which are already in use. Speaking only in terms of television broadcasting, the central television station already plans to increase to 8 sets of programs. Besides this, there are already close to 20 provinces and cities that have applications to the broadcast electronics ministry. They plan to raise their own money for expenses associated with renting transponders in order to realize provincial and regional television and transmission of broadcast programming. The central educational television station is preparing to increase new educational television programs. There is also a requirement to add 1 transponder.

Table 1 Transponders in Use and Actual Numbers Required (End of 1993)

Communications Enterprises	Projects	Transponders Used	Estimate of Actual Needs
Central Television Programs	CCTV Program Sets No.1 and No.2, Central Station Television Programs for Taiwan and Southeast Asia, as Well as Other Exchange Programs	6	8
Local Television Programs	Television Programs Associated with Such Provinces and Cities as Those of Yunnan, Xinjiang, Sichuan, Tibet, Shandong, Qinghai, Gansu, Fujian, Zhejiang, and So On	6	15-16
Educational Television	CETV Program Sets 1 and 2, Tibetan Language Educational Programs, and Local and Regional Educational Television Programs	2	3
Audio Broadcasting, Etc.	30 Channels at the Central Peoples Broadcasting Station of Transmissions Directed Abroad and Information Transmitted for Internal Use	1	1
Public Postal and Telecommunications	Public Telephone Nets	6*	15
Specialized Departmental Communications	Data, Specialized Television Communications VSAT and TES** Services	3	5
Communications Associated with Financial and Information Networks	Specialized VSAT and TES Communications		2-3
Total		24	49-51

* Is 6 72MHz transponders, capable of being the equivalent of 12 36MHz transponders.

** TES is Telephone Earth Station

The earth stations that were put into operation early on in association with public communications networks were only Beijing, Lhasa, Kunming, Guangzhou, Chengdu, as well as Huhhot stations. Recently, delivery has been taken of a batch of 13-16 meter stations, including such places as Xiamen (Amoy), Fujian, Shanghai, and so on, with a total of 12. The amount of service is approximately 7500 bidirectional voice channels. The total requirement for transponders is approximately 15. As far as specialized communications networks used in related central departments are concerned, at the present time, they only account for 3 transponders. At the end of 1993, the need is for approximately 5 transponders. /4

Following along with reforms associated with the economic system, there is an urgent need on the part of the nation and a number of provinces and cities to make use of satellite communications to realize regional or pannational voice communications as well as networks associated with information, data, remittances, stock, and negotiable securities. With regard to the outlook for transponder requirements, they are considerable. According to conservative estimates, there is a need for 2-3 transponders. Table 1 does detailed comparisons, giving transponders in use at the present time and actual numbers required.

II. PREDICTIONS OF THE FEATURES OF THE SATELLITE COMMUNICATIONS MARKET IN THE YEAR 2000

1) Overall Analysis of Trends in Needed Market Developments

With regard to the situation predicted in the satellite communications market, consideration should be given to the several factors discussed below--the speed of growth in the national economy, development stages in which various satellite communications services are situated at the present time, as well as the status of requirements associated with satellite communications services in the next few years.

Table 2 Status of Domestic Economic Growth Since 1980 (Unit %)

(1) (2) (3) (4) 单位:%)

项目 (1) / 年份 (6)	国民生产总值 (2)	社会总产值 (3)	工农业总产值 (4)	国民收入 (5)
1980年 (7)	7.9	8.4	7.5	6.4
1981年	4.5	4.4	4.6	4.9
1982年	8.5	9.5	8.8	8.2
1983年	10.2	10.2	10.2	10
1984年	14.5	14.7	15.2	13.6
1985年	12.7	17.1	16.5	13.5
1986年	8.3	10.1	9.7	7.7
1987年	11.1	14.1	15	10.2
1988年	11.1	15.8	17.3	11.3
1989年	4	5.2	7.5	3.3
1990年	5.3	6.5	7.7	4.8
1991年	7.3			
1992年	12.8			

Key: (1) Item (2) Gross National Product (3) Overall Value of Social Production (4) Overall Value of Industrial and Agricultural Production (5) National Income (6) Year (7) Year

a) Growth Rate of the National Economy as a Whole

Based on the statistical data of the "Chinese Economic Yearbook", the status of domestic economic growth since 1980 is seen in Table 2.

It is possible to see from Table 2 that, in the last few years, the yearly growth rate of the Chinese national economy is an average of around 9%. Although--due to various types of causes--the annual growth rate of the national economy has fluctuations up and down, the overall trend, however, is still linear growth. In the analyses of this article, it is assumed that, before the year 2000, linear growth will continue to be generally maintained.

b) Development Stages in which Various Satellite Communications Services Are Situated at the Present Time

Due to the pioneering role of the Chinese postal administration services in the national economy as well as their key position, statistical data in "Chinese Economic Yearbook"'s clearly show that, in the last few years, growth has been sustained at annual rates higher than 25%-30% right along. Even though a total of 7500 bidirectional lines have been opened in association with satellite public communications networks, services associated with satellite public communications networks still only account for around 25% of postal and telecommunications public

communication networks and are only capable of satisfying requirements associated with communications services between a few large cities. Because of this, it is possible to say that satellite public communications networks are just in the midst of a development stage associated with sustained growth.

As far as domestic specialized communications networks are concerned, because they are subject to limitations associated with satellite transponder resources, in the last few years, most have been situated in a stage associated with investigation, research, and planning. For example, various national departmental committees such as communications, civil aviation, railroads, customs, trade, and so on, as well as local specialized communications networks have all still not been completely set up. As a result, it is possible to say that, speaking in terms of specialized communications networks, they are still only positioned in a start up phase. Following along with developments of satellite resources in the last few years, specialized communications networks will have a comparatively large development.

Table 3 Status of Domestic Satellite Transponder Requirements 1988-1993

(1) 年份	1987	1988	1989	1990	1991	1992	1993
(2) 实际使用的卫星转发器	6	9	11	14	15	16	24
(3) 实际需要的卫星转发器	10	11	15	19	27	38	50

注：年份均为年底 (4)

Key: (1) Year (2) Satellite Transponders in Actual Use (3) Satellite Transponders Actually Required (4) Note: Years Are All by End of Year

With regard to satellite broadcast television services, they are subject to limitations associated with satellite transponder resources in the same way. It is only possible to satisfy broadcast television services associated with the Center and a small number of provinces and regions. However, at the present time, television stations which exist domestically are already over 600. There are already close to 20 television stations which have requested satellite television program propagation. Due to the opening of Zhongxing No.5 satellite service as well as the launch of the East 3 communications satellite at the beginning of 1994 and its beginning to be used, satellite broadcast services will have a

large development. Following along with a day by day growth in the requirements of people associated with cultural and mental life as well as the impressive economic advantages associated with satellite television at the present time, the prospects for satellite television broadcast services look good.

c) Status of Requirements Associated with Satellite Communications Services in Recent Years

Investigation and research was carried out on related areas with regard to the status of actual requirements associated with satellite transponders by users and satellite transponders actually in use in domestic satellite communications and television broadcasting. Table 3 sets out the state of investigation and research associated with the requirements of domestic users in regard to satellite transponders from 1988 to the end of 1993.

The explanation of Table 3 data is that, in recent years, due to being subject to limitations associated with domestic satellite space resources, satellite transponders have already been placed into a situation where supply does not meet demand. Actual user satellite transponder requirements are growing at an average annual rate of 25%-30%.

2) Predictions of Trends in the Development of Market Demand

From the data in Table 2 and Table 3, it is possible to see the speed of growth of the Chinese national economy and the growth in the number of requirements by domestic users on satellite transponders. Although there are fluctuations up and down from time to time, basically, the trend is linear growth, however. Giving consideration to domestic satellite communications service networks and satellite television still being in a start up phase, and satellite public communications also being in a development phase associated with sustained growth, as a result, in predictions, assuming that satellite communications requirements will also follow a linear growth pattern, it is not possible to believe that moving forward is premature. In this way, it is possible to carry out predictions in accordance with one dimensional linear regression analysis methods on satellite communications market demand before the year 2000. /5

On the basis of Table 3 data, carrying out extrapolation in accordance with time order trends, it is then possible to solve numerical equations predicting amounts of satellite transponder demand:

$$Y(\text{illegible}) = 26.7 + 7.77 \times (T - To)$$

In the equation:

Y(illegible): the amount of transponder demand corresponding to year T

T: is a year, figuring from 1988

To: is a constant. To = 1990.5

On the basis of the equation above, it is possible to calculate predicted amounts of satellite transponder demand before

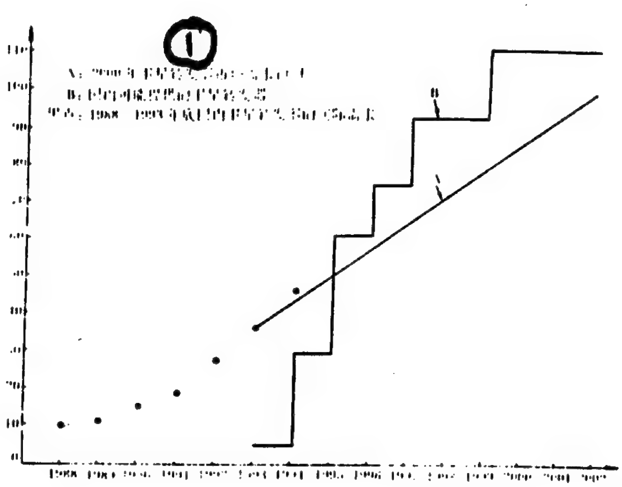
the year 2000 (see Table 4 and appended Fig.).
The curve A in the appended Fig. is the demand trend prediction for domestic satellite transponders to the year 2000 calculated in accordance with one dimensional linear regression analysis methods. The black dots represent actual demand associated with domestic satellite transponders in the years 1987-1993.

Table 4 Predicted Satellite Transponder Demand Before the Year 2000

① 年 份	1988	1989	1990	1991	1992	1993	1994
② 预测数	8	15	23	31	38	46	54
① 年 份	1995	1996	1997	1998	1999	2000	2001
② 预测数	62	69	77	85	93	100	108

Dec. 1993 *Aerospace China*

Key: (1) Year (2) Predicted Number



Shape Graph for Amounts of Domestic Satellite Transponder Demand Before the Year 2000 (1) [Illegible]

III. DOMESTIC SPACE TRANSPONDER RESOURCES BEFORE THE YEAR 2000

The design life of the East 2A satellites, which are in use at the present time, is 4 years. Satellite orbital control fuel was loaded in accordance with the LM-3 rocket orbital error 3σ probability range. However, the actual orbital entry errors for

each LM-3 rocket were within the range 1σ. The fuel carried by the satellites to overcome orbital insertion errors, which was saved, can be used in extending the orbital maneuver life of the satellites. Analysis results clearly show that, when 3σ errors are reduced to 1σ, it is possible to extend orbital maneuver life half a year. Moreover, extending life in orbit half a year--speaking in terms of electric power sources and temperature control systems--can be recognized as still within the range of design margins. As a result, as far as the East 2A satellite operating life is concerned, in addition to being within the original fuel design margins, on the basis of 5 years (or even somewhat more time), considerations are comparatively appropriate. For this reason, it is possible to believe that the East 2A A (launched in March of 1988) will operate until the last half of 1993 and the East 2A B (launched in December 1988) can operate until the first half of 1994. When setting up the plan for space resources--acting as a comparatively conservative arrangement--beginning in 1994, the East 2A satellites should not be considered again.

The Zhongxing No.5 opened communications in August 1993. It will operate until the end of 1996.

The first East 3 satellite is planned for launch in the first half of 1994. It will open communications and operate in the middle of 1994. On the basis of analyses looking at such factors as the improved reliability of space sections and the actual status of launches abroad--with regard to the East 3 satellite, which possesses an 8 year life and 24 transponders--it is best that the second satellite generally select a launch 1.5-2 years after the first satellite. As a result, with regard to the second East 3 satellite and the Zhongxing No.5 satellite, it is possible to believe that, basically, in terms of time, they are providing service in a "series connected" form. Besides this, domestically, it will be possible, on the basis of market requirements, to launch one specialized domestic communications satellite before the end of 1996. It has 18 transponders. It is assumed that a second satellite will be launched two years later.

APSTAR-1 has 24 operating transponders. Because it is capable of providing service to the Southeast Asia area, it is also able to be rented out to other users abroad. As a result, it is assumed that, at a maximum, it will be possible to provide 12 transponders for domestic service. APSTAR-2 is planned for launch at the end of 1994 or the beginning of 1995. It has a total of 34 transponders. Among these, something less than half the transponders will be able to provide domestic service.

On the basis of the analysis described above, Table 5 summarizes satellite space resources which are capable of providing domestic applications within the time period 1994-2000. See curve B in the appended Fig.

IV. PREDICTIONS OF THE SHAPE OF SUPPLY AND DEMAND ASSOCIATED WITH THE DOMESTIC SATELLITE COMMUNICATIONS MARKET

Summarizing what was described above, it is possible to obtain

predictions of the shape of supply and demand associated with the domestic satellite communications market before the year 2000 (See Table 6). /6

From the results in Table 6, it is possible to see that,

1) 1993 is a year when domestic civilian transponders are most urgently short. By 1995, there are 60 transponders which can be used domestically. Supply and demand are roughly in balance. After 1988, supply is slightly greater than demand. As a result, it is possible to say that domestic satellite communications resource conditions are getting better and better.

Table 5 Space Transponder Resources Capable of Being Supplied Domestically Before the Year 2000

表5 2000年前可能提供国内的空间转发器资源

	频段	转发器个数				功率 (W)	EIRP 边缘 (dBW)	带宽 (MHz)
		1994	1995	1996	1998～2000			
东三(第一颗)	C	24	24	24	24	18×8W 6×16W	34 37	36.0
东三(第二颗)	C			24	24	18×8W 6×16W	34 37	36.0
其它国内专用通信卫星	C Ku			12 6	12 6	12×8/16 6×50W	33/36 43	36.0 72.0
其它国内专用通信卫星	C Ku				12 6	12×8/16 6×50W	33/36 43	36.0 72.0
中星五号	C Ku	18 6	18 6			12×8W 6×16W 6×16W	30.5 33.5 35	36.0 72.0 72.0
APSTAR 1*	C	12	12	12	12	16W	34	4;72.0 8;36.0
APSTAR 2*	C Ku Ku		6 6 2	6 6 2	6 6 2	55W 50W 100W	38 41～51 45～55	6;36～64 6;54.0 2;54.0
总 计	C Ku	54 6	60 14	78 14	90 20			

* 只列出有可能提供给中国使用的转发器

Key: (1) Frequency Band (2) Transponder Number (3) Power (4) Edge (5) Band Width (6) East 3 (First Satellite) (7) East 3 (Second Satellite) (8) Other Specialized Domestic Communications Satellites (9) Other Specialized Domestic Communications Satellites (10) Zhongxing No.5 (11) Total (12) * Only Sets Out Transponders Capable of Supplying Service to China

Table 6 Shape of Supply and Demand Associated with Domestic Satellite Communications Transponders Before the Year 2000

1 年份(年底)	1992	1993	1994	1995	1996	1997	1998	1999	2000
2 需 求	36	46	54	62	69	77	85	93	100
3 提供数	5	29	60	74	92	92	110	110	110

Key: (1) Year (Year End) (2) Demand (3) Number Supplied

2) The analysis above is based on successful launches of two The East Is Red No.3 communications satellites. In conjunction with this, the development and launch again after 1996 of two specialized communications satellites is considered. If 4 satellites go aloft before the year 2000, a comparatively optimistic projection should be believed. If the plans described above are not able to be implemented on schedule, it will then still alter the shape of supply and demand.

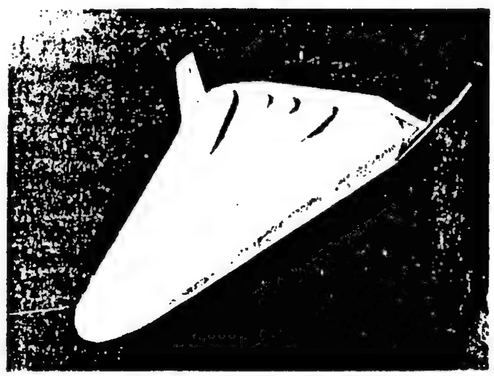
3) In calculations for transponders that are available, the figuring included the APSTAR-1 and APSTAR-2 satellites, which were not dependent on autonomous development by China. If consideration is only given to satellites that were independently developed by China, then, in 1995, it would temporarily not be possible to satisfy the amount of market demand. In 1998, supply demand relationships are maintained basically in balance. After the year 2000, a situation where supply does not meet demand will appear again.

SINGLE STAGE ORBITAL ENTRY CONCEPT PUT FORWARD BY THE LOCKHEED COMPANY

Sun Bo

Translation of "Luo Ke Xi De Gong Si Ti Chu Dan Ji Ru Gui De She Xiang"; Aerospace China, No.12, December 1993, p 28

Research personnel associated with one plant of the U.S. Lockheed company recently put forward an idea for a type of unmanned single stage orbital entry spacecraft. They say that this type of space vehicle is capable of lowering the cost of each kilogram of useful load inserted into orbit to 1100 U.S. dollars or even lower. Moreover, not long after the year 2000, it will then be capable of going into service.



An Aeroballistic Rocket Type of Single Stage Orbital Entry Spacecraft Put Forward by Technical Personnel of a Plant of the Lockheed Company

The propulsion system associated with this type of spacecraft will opt for the use of linear blocked types of injection pipes. The entire propulsion system is composed of a parallel arranged set of 7 engines. After combination with a lifting body type of fuselage, it forms an aeroballistic rocket spacecraft capable of taking 18 ton useful loads and sending them into 185 kilometer high low earth orbits (this capability is equivalent to the Atlas 4). It is also capable of use in taking space stations and launching them into 556km high orbits. According to the concept, it will fly each time for 12-72 hours in orbit. After that, it will return to

the surface, opting for the use of conventional wheel type landing methods and landing on a runway. The spacecraft in question will be of an unmanned type. However, its first few flights will be piloted by a cosmonaut.

Blocked type injection tube engines are a 1960's design. At that time they were prepared for use in replacing bell type injection tube engines. After that, in accordance with linear and ring shaped arrangements, 260 iterations of hot running tests were carried out on this type liquid hydrogen liquid oxygen motor. At the present time, the linear arrangements that are used are capable of carrying out combinations with fuselages very well.

The thrust to weight ratio for this type of Lockheed company aeroballistic spacecraft is 1.4 (vertical take off). If, during flight, there is an engine that develops malfunctions, the corresponding motor on the other side is automatically shut down. In this way, the entire spacecraft is then still able to safely carry out emergency flight--not going as far as creating difficulties in control because of thrust asymmetry. According to calculations--in this type of situation--the spacecraft will be capable of continuing to fly--burning up the fuel it carries. After that, it lands safely in a situation guaranteeing that the useful load is not damaged.

During reentry, the lift to drag ratio of the spacecraft in question is predicted to be smaller than 1. The glide properties in supersonic flight are not as good as the current U.S. space shuttle. However, the glide performance during low speed flight is comparatively good. The designs of the lower surface of the fuselage and the flight cross section both give consideration to aerodynamic heating problems. The lower surface of the fuselage will make use of an aerodynamic heating protection layer manufactured from titanium or similar materials. In order to lower costs, the protective layer in question will not make use of ceramic materials.

According to estimates, the development of a practical model of this type of spacecraft requires approximately 5 billion U.S. dollars. Unit production cost is 475 million U.S. dollars. Besides this, there is also a requirement for 250 million U.S. dollars in life cycle spare parts. Along with this, each flight also requires 300 million U.S. dollars in consumables (primarily fuel consumed). The life of each spacecraft is 20 years. It requires a maintenance contingent of 150 people. Each year, it is capable of carrying out over 30 launch missions. Moreover, users only need to carry out 15-20 launches each year, and it is then possible to take the cost of putting each kilogram of useful load into orbit and keep it at under 1100 U.S. dollars.

U.S. NAVIGATION SATELLITE GLOBAL POSITIONING SYSTEMS

Zhang Ziqin

Translation of "Mei Guo De Dao Hang Xing Quan Qiu Ding Wei Xi Tong"; Aerospace China, No.12, December 1993, pp 29-32

As far as the new generation of U.S. satellite navigation systems--Navstar GPS--which was jointly developed and managed by the U.S. Defense Department's land, sea, and air services, is concerned, it has already completed this year's June 26 deployment three months ahead of time. In conjunction with this, it has gone into full service.

This project cost over 3 billion U.S. dollars. It was completed jointly by the three U.S. military services. The Air Force acted as the Defense Department's general representative in overall control of this project. In conjunction with this, the spaceflight section of Air Force Headquarters set up a joint project office composed of such departments as the Army, Navy, Air Force, Defense Mapping Agency, as well as the U.S. Department of Transportation, and so on--taking charge of the day to day operation of the system.

I. SYSTEM COMPOSITION

With regard to the Navstar global positioning system, it is also called "the navigation satellite time and range finding/global positioning system". The system is composed of three basic parts--a space section, a ground control section, and the users.

Space Section It is composed of 24 navigation satellites (21 operating satellites and 3 back up satellites). They are distributed in 6 earth orbital planes equidistant from the ground (each orbital plane has 4 satellites). The orbital altitude is 17540km. The angle of inclination is 63 degrees. The period is 12 hours. The main specialized equipment on board satellites is high stability and high precision atomic clocks (the accuracy is one second/300 thousand years), navigation text storage devices, as well as radio dual frequency transmitters, and so on. The operating frequency band associated with the dual frequency radio transmitters is the L wave band. The transmitters on each satellite all use 1575.42 megahertz (L_1) and 1227.6 megahertz (L_2) to sent two types of false random noise frequency spectrum expansion navigation signals. Users at any place on earth and at any time are capable of continuously receiving navigation signals associated with 4 navigation satellites.

Ground Control Section

It is composed of a central control station set up at the U.S. unified spaceflight center, 3 up link stations, and 5 global

monitoring and control stations. The missions of the ground control section are to track, measure, and control the operating orbit of each satellite in navigational satellite constellations, calibrating the clocks on the satellites, as well as composing and changing the navigation texts sent from satellites to users, and so on.

User Section

It is composed of a series of user equipment. User equipment generally includes navigation signal receivers, data processors, as well as different forms of control/display equipment or input/output equipment, and so on. This equipment can be carried on different types of platforms such as aircraft, ships, vehicles, missiles, spacecraft, etc. User sections also include portable forms of GPS receivers used by single persons. User equipment and single person portable types of receivers are able to precisely give such data as locations where users are, accurate times, as well as user (target) movement velocity vectors, and so on.

II. SYSTEM DEVELOPMENT AND OPERATING PRINCIPLES

Satellite navigation developed on the foundation of traditional astronomical navigation and the radio navigation of recent times. It overcomes the constraints of weather conditions which astronomical navigation is subject to and the weak point of comparatively large errors associated with radio navigation in medium and long distance ranges. It is capable of continuously providing precise navigational data at all times and in all weathers for various types of ground, maritime, aerial, and outer space users and various types of targets.

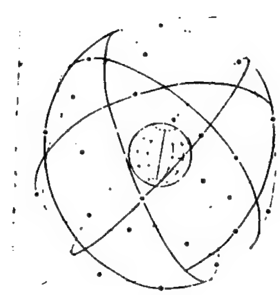


Fig.1 Navstar Global Positioning System Satellite Orbital Distribution Schematic

Up to now, satellite navigation has already developed two generations. The Navstar GPS system was developed as the second generation system of navigation satellites, following after the U.S. TRANSIT navigation satellite. In 1973, the U.S. Defense Department went through deliberations and decided to test manufacture and develop the Navstar global positioning system. In conjunction with this, it approved system design plans. The subplans of the system project were verified. There was full dimension test manufacture, and it went into service in three phases. It was set up on a plan to use it for 20 years. In 1979, there was comprehensive development of test manufacturing operations. Due to the feasibility of designs, in reality, after full dimension test manufacturing operations, it then entered into the phase of practical utilization.

The Navstar global positioning system is a passive navigation system. It opts for the use of dual frequency false random noise range finding navigation set ups. Its operating principles are to use time range finding in order to figure and solve for three dimensional coordinates associated with user (target) locations. First of all, users receive navigation signals sent out by navigation satellites. The product of navigation signal propagation times and electromagnetic wave propagation speeds is nothing else than the instantaneous distance of satellite and user. If user reception functions simultaneously receive navigation signals associated with 4 navigation satellites, it is then possible to solve for world geodetic coordinate system (WGS-72 coordinate system) data associated with the three dimensional location (longitude, latitude, and altitude) of users (targets) or convert into other coordinate system data needed by users. In conjunction with this, it is shown on receiver display screens. At the same time as this, the system is also capable of supplying for users precise time and user (target) motion velocity data. The positioning accuracy is on the meter level. Time calibration precisions are $1x10^{-6}$ seconds. Speed measurement precisions are 0.1 meter/second. /30

Due to systems opting for the use of multiple satellite constellations and radio positioning set ups, therefore, completion of each iteration of positioning only requires a few seconds to a few tens of seconds of time. Without doubt, this type of positioning system and positioning accuracy, in the military--particularly, with regard to users (targets) that are in the process of moving, such as tanks, aircraft, missiles, spacecraft, and so on, as well as troops carrying out combat missions under unfamiliar and complicated terrain conditions--possesses particularly important significance. In the appended Table is set out a comparison of data associated with the performance of three types of military navigation systems.

III. SYSTEM APPLICATIONS

The Navstar global positioning system has wide spread applications in the military. In modern technologies--particularly, under conditions where high technology is comprehensively used in war--such characteristics as the real time nature of system operations, speed, the accuracy and comprehensive nature of data, the global nature of spacial coverage ranges, as well as--in terms of time--the capability for all weather coverage at any time then show even more the special position and role of it in modern wars. The value of utilizing the Navstar global positioning system lies in its ability to make the combat power of military units achieve a certain level of increase--famous as the "multiplier" of the combat power of weapons, equipment, and military units. In actuality, the Navstar global positioning system is already and is in the process of becoming the primary and universal navigation positioning system of the three U.S. land, sea, and air services.

(1) (2) (3) 军用导航系统性能比较 (5) (6) (7)

系统名称	覆盖范围	精度	通用网格坐标 (4)	用户数目	抗干扰	多值性
(8) 惯性导航系统	(11) 全球	(12) 随时间变化	单一 (15)	(16) 无限	(17) 无穷大	无 (18)
(9) 子午仪卫星导航系统	(11) 全球	(13) 50米	WGS-72	(16) 无限	(18) 无	(20) 速度补偿
(10) 导航星全球定位系统	(11) 全球	(14) 10米	WGS-72	(16) 无限	(19) 55分贝	无 (18)

Comparison of Military Navigation System Properties (1) System Nomenclature (2) Coverage Range (3) Precision (4) Universal Grid Coordinates (5) No. of Users (6) Counter Interference (7) Multiple Value Characteristics (8) Inertial Navigation System (9) TRANSIT Satellite Navigation System (10) Navstar Global Positioning System (11) Global (12) Changes with Time (13) 50 Meters (14) 10 Meters (15) Unitary (16) Unlimited (17) Infinitely Large (18) None (19) 55 Decibels (20) Speed Compensated

Applications of the Navstar global positioning system in the military involve applications on land, applications at sea, applications in the air, and applications in space--all these many areas and realms.

The Navstar global positioning system is capable of providing precise positioning data for land based strategic missile bases,

tactical missile units--in particular, for mobile tactical missile unit bases and firing locations. It is capable of correcting flight trajectories for ballistic missiles in flight and reentry phases, as well as supplying possible mid course corrections for ballistic missile test measurement instruments, thereby very, very greatly improving weapon hit accuracies and attack results. It is capable of gauging the precise locations of the fixed and mobile positions associated with such modern maneuver units as ground units (including single military personnel), armored troops, artillery troops, army aviation troops, and so on, thereby improving weapon hit accuracies--increasing unit maneuver capabilities, fire support capabilities, and capabilities for coordinated combined arms combat under modern conditions.

What is worth pointing out is that, due to the fact that the system possesses all weather continuous navigation capabilities anytime, it is, therefore, an extremely useful and rare system with regard to the deployments of maneuver airborne units and secret surprise attack activities.

Maritime applications include oceanic patrolling, rendezvous of special types of detachments at sea, port and landing ground navigation, as well as appropriate use in a number of aerial application areas and projects associated with oceanic applications.

Acting as the principal navigation system, its aerial applications include providing mid course navigational safeguard capabilities for air force strategic and tactical activities, combining with inertial survey equipment or its navigation equipment, improving and raising aerial navigation capabilities, as well as improving weapon hit precisions during air raids and air campaigns as well as attack results, and so on.

Space applications are principal and potential realms of application for global positioning systems. They are capable of providing precise positions and speed measurement data for spacecraft in flight. After the mounting of global positioning system user equipment on low earth orbit military reconnaissance satellites and other military and civilian satellites, it will very, very greatly lower the requirements for ground station tracking and extensive computing capability on board satellites.

As far as these functions and roles associated with the Navstar global positioning system are concerned, during the Gulf crisis of 1990 to 1991 and the carrying out of the Gulf War against Iraq by multinational units with the U.S. at their head, they have already achieved full empirical verification. Although the system only had 16 satellites in operation at that time, it still played a decisive role in the rapid achievement of victory in the war for the U.S. led multinational units, however. In particular, with regard to the shortage of land marks, speaking in terms of Middle East battlefields that are one great desert prospect with no markers and multinational units that are fighting in strange countries far from their native lands, the role of Navstar is even more prominent.

It is reported that, during the period of the Gulf crisis and the Gulf War, the U.S. Trimble company alone then supplied for the Defense Department over 3000 units of portable type GPS receivers. The external dimensions of this type of receiver are 16.5x17.8x5.1 cm. The weight is 1.89kg. Positioning precision is 25 meters (circular error probability). During this period, the U.S. Maizhelun (phonetic) company also supplied portable receivers to multinational units at a speed of production of 1000 units each month. The external dimensions of this type of receiver are 22x9x5 cm. The weight is 0.81kg. It is possible to carry them inside the pocket of a uniform jacket. During the war, U.S. units participating in the battle installed GPS receivers produced by the Trimble company on most aircraft, tanks, vehicles, and so on. U.S. troops participating in the battle, by contrast, were equipped with portable receivers produced by the Maizhelun (phonetic) company./31

During the war, the air forces made use of Navstar to precisely specify aircraft positions in order to carry out precision air raids and bombing against Iraq. The navy warships participating in the battle used it for navigation and to precisely specify the positions of mines which Iraq had laid in the ocean, causing warships to go through mined areas smoothly. Ground artillery made use of Navstar to precisely specify the locations of friendly positions and the coordinates of enemy targets. Main battle tanks and refueling vehicles made use of Navstar to precisely specify their own positions, directions of advance, and driving speeds in order to facilitate accurate rendezvous and timely replenishment of fuel. Ground units made use of portable receivers to precisely specify locations, indicate directions, and carry out combat missions. It is said that, then, even U.S. F-16 fighters that were shot down by Iraqi forces had their pilots also rely on precise location data supplied by Navstar and only then did they obtain timely rescue by helicopter.

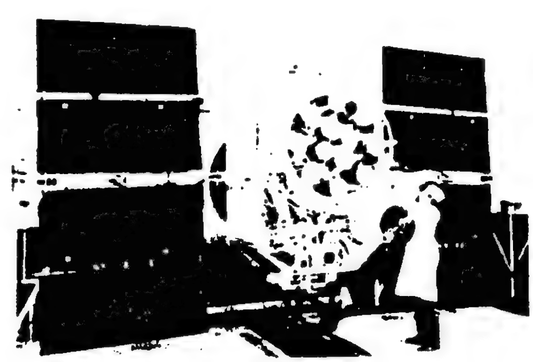


Fig.2 Navstar Global Positioning System Satellite

Fig.3 Portable GPS Receiver Produced by the U.S. Maizhelun (Phonetic) Company

Although the Navstar global positioning system is a type of military satellite navigation system financed, developed, managed, and used by the U.S. Defense Department, the U.S. Defense Department did not, however, ignore and give up its utilization value in the area of civilian uses. However, the signals which can be gotten by military receivers were secured. Receivers for civilian uses are only able to get a type of unsecured navigation signal. This type of navigation signal, which is sent out by satellites, intentionally lowers the level of positioning accuracy, making the positioning precision fall to reliabilities of 95% at 100 meters. Reliabilities are 99.99% at 300 meters. However, if option is made for the use of error display global positioning systems, this type of signal error is still completely correctable. The method is to use a receiver unit that is fixed and unmoving at a point with known coordinates. First of all, measurements are made of the error between the position coordinates supplied by Navstar and the coordinates that are already known. After that, it is then possible to lower the signal error, thereby taking low level signal precisions and raising them to the meter level (error range is 1-5 meters). At the present time, No.2 among the International Maritime Communications Satellites opts for the use of none other than this type of method, making use of the Navstar global positioning system in order to carry out positioning. /32

At the present time, although, in terms of civilian uses, full extension and application of the Navstar global positioning system still has certain difficulties associated with it, the prospects for its application in the area of civilian uses as well as its potential power, however, go without saying and cannot be ignored. In reality, the system is already widely used in all such various realms as civil aviation, maritime navigation, land and sea rescue, geological prospecting, and even recreational mountain climbing and tourist travel. As far as the U.S. is concerned, the relevant areas have recently gone through testing which clearly shows that

using the Navstar global positioning system in the navigation and management of civil aviation systems is--compared to ground navigation equipment--capable of more precisely and more flexibly supplying less expensive navigational services for civilian aircraft. The Navstar global positioning system is also capable of guiding more civilian passenger planes into optimum flight paths in order to facilitate shortening flight times, saving fuel, and extending aircraft service life. It is said that the U.S. Federal Aviation Administration has intentionally provided satellite navigation services to civilian aircraft from various nations of the world free of charge. There need be no doubt that, following along with the development of satellite navigation technology, the software and hardware which form a set with it are being perfected day by day as well as the price of GPS receivers being lowered. Nonmilitary users will necessarily expand a step further. Just as experts predicted, the Navstar global positioning system will change into a way of managing a good number of industries.

ATLAS ROCKET GIVES RISE TO EXPLOSION INCIDENT

Sun Bo

Translation "Da Li Shen Huo Jian Fa Sheng Bao Zha Shi Jian"; Aerospace China, No.12, December 1993, p 32

On 2 August, the U.S. Atlas 4 rocket gave rise to an explosion during the carrying out of an Air Force launch mission. This is the spaceflight accident with the most severe damage since the 1986 loss of the Challenger space shuttle. This incident caused the destruction of an Air Force military use satellite. This satellite may have been the KH-11 advanced digital imagery satellite. It may also have been the Lacrosse imagery radar satellite or an advanced oceanic electronic reconnaissance satellite used in intercepting the content of voice communications between ships. On the basis of estimates, the loss of the useful load and delivery means alone is then capable of reaching 1.5-2.0 billion U.S. dollars.

Atlas 4 Fired Aloft

This instance of launch was carried out at the Vandenburg Air Force Base No.4 launch facility. The explosion occurred 101 seconds after the rocket went aloft. At this time, the rocket was just in the process of beginning a programmed turn. Before the occurrence of the explosion, the rocket was in the process of normal flight. After that, there appeared around the body of the rocket a ring of white smoke. In conjunction with this, it

expanded rapidly in all directions. Immediately following that, there appeared a fire ball and billows of black smoke. Big pieces of the rocket fuselage wreckage fell onto the surface of the sea.

At the present time, as far as relevant areas are concerned, the carrying out of analysis has already begun with regard to the various important systems of the rocket (including the liquid propellant core stage constructed of two levels, engines, thrust vector control systems, avionics equipment, guidance systems, and solid rocket motors). Preliminary analysis clearly shows that this instance of explosion was given rise to by one side wall in the rocket's two solid motors burning through. This failure caused launch operations associated with the Landsat 6 (originally set for launch on 5 September on the Atlas 2) to be delayed. However, if the conclusion described above is realistic, and there are sufficient solid motor sections that are capable of service, two Atlas 4 launch missions making use of Centaurus upper stages will not be too greatly influenced. The delay of the Atlas 2 launch was associated with fears that interchangeable components in the rocket in question and the Atlas 4 were involved in this accident. The Atlas 2 is a refit of an intercontinental ballistic missile. It is capable of taking a useful load of approximately 2180 kilograms and sending it into a circular polar orbit of 180 kilometers.

Besides this, the improved model solid rocket motors (SRMU) to be used by the Atlas 4 will carry out their final static test runs in the near future. The decision to develop this type of motor was made at the end of the 1980's. The objective is a desire to go through a design associated with manufacture opting for the use of automated production technology and a division into three sections (is now 7 sections) in order to improve the reliability of the Atlas 4. The improved model solid motors will still opt for the use of omnidirectional injection tube installation and composite material shells (but not steel).

At the present time, as far as the lay outs of the Atlas 4 and 5 are concerned, three types among them do not carry an upper stage. Another two types respectively carry Centaurus upper stages and Inertia upper stages. Atlas 4's carrying Centaurus are the only type of lay out that has not gone through flight service test verification. Carrying out of two launch iterations was originally set for within the year. Atlas rockets had two launch failures in 1985 and 1986.

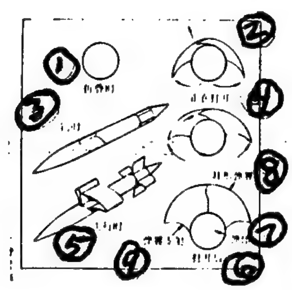
HUGHES COMPANY RESEARCH NEW MODELS OF MISSILE WING DESIGN PLANS

Zhang Zhong

Translation of "Xiu Si Gong Si Yan Jiu Xin Xing Dan Yi She Ji Fang An"; Aerospace China, No.12, December 1993, p 33

The U.S. Hughes company is in the midst of setting up ways to find U.S. Air Force funding in order to empirically verify a type unfolding form of missile wing design plan. This brand new type of wing form design plan is capable of increasing the range of air launched models of weapons. Opting for the use of this type of ring shaped wing, drag is small. Placed in a loaded configuration, the space it takes is small. At the present time, the Hughes company is just in the midst of doing research on taking it and using it on unguided bombs as well as the "Maverick" missile which the company in question produces.

This type of ring shaped wing has a flexible belt. After weapons are released, the flexible belt which is wound around the bomb or missile body springs open outward and upward. After control surfaces, which are wound around the tail section, open out, it is possible to carry out stabilization and control of the weapons.



Hughes Company's Ring Shaped Missile Wing Design Plan

Key: (1) When Folded (2) In the Process of Opening Up (3) During Transport (4) In the Process of Opening Up (5) In Flight (6) After Opening (7) Missile Body (8) Ring Shaped Missile Wing (9) Missile Support Frame

The Hughes company has already carried out wind tunnel tests with regard to model missiles associated with ring shaped wings. During the experiments, the flexible belts used are made from 1mm thick aluminum alloy. There is deployment and lock in of missile wings within 0.2 seconds.

The Hughes company has already proposed to the U.S. Air Force the carrying out of a two year testing and verification project. The Hughes company is preparing to use pulleys to take missile bodies and accelerate them to flight speed, after which, they are launched. Following launch, the tail fins open out first in order to stabilize the missile body. After that, the missile wings open out.

It is said that opting for the use of this type of deploying missile wing is capable of making the range of weapons on the order of 1000 kilograms increase by one fold. The terminal maneuver overloads can increase over two fold.

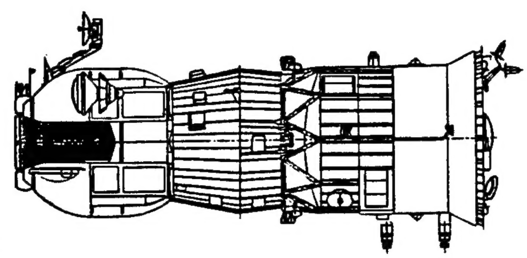
This type of ring shaped missile wing is also capable of use in air to air missiles.

RUSSIA'S FIRST USE OF RECOVERY COMPARTMENT SAMPLES

Wen En

Translation of "E Luo Si Shou Ci Yong Hui Shou Cang Qu Yang"; Aerospace China, No.12, December 1993, p 33

On 4 July of this year, Russia recovered a returnable compartment called Rainbow carrying Peace space station experimental samples and data. This compartment successfully fell within the borders of Russia.



The Rainbow Compartment (Shaded Section) Positioned on the Progress

The Rainbow compartment is capable of carrying back as much as 150 kilograms of experimental samples, data records, and so on from the Peace space station. The Rainbow compartment was designed by the Energy Source design bureau. Before this, the only way to send back samples from manned space stations relied on the Union manned spaceship.

The Rainbow compartment was sent up to the Peace space station by the Progress M-18 spaceship on 24 June. After docking of the Progress spaceship and the space station, the experimental items which it was desired to send back to earth were loaded into the Rainbow compartment by Cosmonauts. Before the Progress returned, the Rainbow compartment went through ejection and separated from the Progress spaceship. In conjunction with this, it carried out a soft landing relying on parachutes. Recovery personnel positioned it based on the Rainbow compartment's radio beacon, and, in conjunction with that, it was recovered.

The Energy Source design bureau is in the process of developing a large model useful load recovery compartment with

better maneuver characteristics. It is capable of being used in the recovery of microgravity experimental items. It is also even capable of use in the escape of space station personnel.

ZHONGXING NO.5 PUT INTO FORMAL OPERATION

Translation of "Zhong Xing Wu Hao Tou Ru Zheng Shi Yun Yong"; Aerospace China, No.12, December 1993, p 6

According to carried reports, China's first orbital communications satellite that was procured outside China--Zhongxing No.5--beginning 15 April, floated from airspace at 120° west longitude above the U.S. Through the course of 72 days, the path of the floating was over 100 thousand kilometers. On 26 June, it was positioned in equatorial airspace at east longitude 115.5°. Early on the morning of 16 July, the Zhongxing No.5 was formally put into operation. The status of operations during several months clearly shows that television transmissions broadcast by the satellite in question as well as the quality of domestic trunk line communications services are good.

The Zhongxing No.5 is a three axis stabilized large model communications satellite manufactured by a U.S. communications electronics company. There are 22 transponders on the satellite. The satellite in question was launched in 1984. The original name was "Spacenet-1". It was a domestic communications satellite utilized by the U.S. Its design life was 12-13 years. At the end of 1992, this satellite, which had already been in orbital service close to 9 years, was purchased by China. The name was changed to be Zhongxing No.5. On the basis of acceptance testing after the shifting and positioning of the satellite, the satellite in question is capable of operating until the end of 1996 in a situation where placement precision is maintained.

After Zhongxing No.5 is put into service, the served area will cover the territory of China comparatively well along with some of the peripheral nations and regions. It is capable of providing multiple types of communications services such as television broadcast transmission, telephone, telegraph, as well as data transmission, and so on. It is also capable of supplying Ku wave band services which China is in the process of developing at the present time.

At the present time, the Zhongxing No.5 has already taken over services from the total of 12 transponders on the original two domestically produced East Is Red No.2A communications satellites as well as the rented international communications satellite organization's V-F7 satellite. These satellites--whether because of already having reached their design life or because of orbital plane inclination--are already unable to carry the burden of the original services. Transmission tasks associated with a total of 6 sets of programs such as the No.1, 2, and 3 sets of programs of the central television station and the Tibet, Xinjiang, and Sichuan television stations have already been undertaken by Zhongxing No.5. The programs of the Shandong and Zhejiang television stations will

also be transmitted by Zhongxing No.5 the beginning of next year. Besides this, this satellite will also take over communications tasks associated with 5200 bidirectional circuits of the postal and telecommunications public communications networks as well as communications missions associated with such specialized communications networks as traffic, civil navigation, customs, capital steel, and so on. The 22 transponders on the satellite are already sold out.